General Comminution Inc.

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Reg. No. 3-9048

INVESTIGATION OF LOW COST TECHNOLOGY
IN COAL CLEANING USING THE
SZEGO NDING MILL SYSTEM

- FINAL REPORT -

PREPARED FOR

MINERAL DRESSING SECTION, CANMET OTTAWA

BY

GENERAL COMMINUTION INC.

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22 pp + 1 fig page

MICROMEDIA

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1. SUMMARY

This document reports on work performed under DSS Contract No. OSQ83-00114.

It includes the manufacturing of a Szego mill, model SM-460-1, experimental work performed on General Comminution premises to verify mill performance for this specific coal grinding application, delivery of same mill and accessories to Devco (Cape Breton Development Corporation) plant (Carbogel pilot plant) in Sydney N.S., system installation, start-up and on site performance testing. The entire project was completed on December 12, 1984 and all performance criteria have been met.

Due to technical problems associated with the development of this prototype unit the entire contract was delayed until satisfactory solutions were implemented. In addition the delivery of a motor starter to provide for smooth starting of the mill was included in the contract.

Recommendations for future system improvements and optimal operation are presented and discussed.

2. INTRODUCTION

Over the past twelve years a considerable amount of attention has been focussed on developing low cost techniques for processing and burning coal in a manner that would make it an acceptable fuel for use in industrial and utility boilers.

Current efforts include both government and private sector programs to develop improved coal cleaning systems, grinding equipment, coal combustion systems, and new coal fuels like coal slurries. The funding level for these various programs ($\sim$ \$60 million in North America), reflects a significant interest in establishing coal as a reliable, cost effective and environmentally acceptable replacement for fuel oil and natural gas.

CANMET in collaboration with Cape Breton Development Corporation has been involved in coal beneficiation using the flotation column technology. The liberation of the ash component from local coals requires excessive grinding ($d_{50} \sim 10$ µm) and the Szego mill was chosen to provide such ultrafine coal. The mill will also be used in grinding coal slurries for other applications.

3. DESCRIPTION OF SZEGO MILL

The Szego mill consists of a stationary, vertical cylindrical surface (stator) and a moving rotor. The rotor comprises a number of helically grooved rollers, suspended by flexible shafts from flanges connected to a central drive shaft. The material to be ground is fed by gravity, or pumped into the mill at the top and is discharged at the bottom of the unit. A schematic diagram of the mill is given in Figure 1.

The particles, upon entering the grinding unit, are repeatedly crushed and sheared between the rollers and the stator. The crushing force is created by the radial acceleration of the rollers and the high velocity gradients that are generated in the mill induce shear.

An important feature is the ability of the roller grooves to aid transport of the material through the mills, thus providing a means to control residence time and mill capacity. Pasty materials can be ground without clogging the mill.

The particular SM-460-1 model has a 46 cm in diameter (I.D.) stator and its rotor houses eight rollers 46 cm long. It rotates at 600 RPM and is driven by a 75 hp motor. A layout drawing is appended.

4. MILL DEVELOPMENT PROGRAM

Two Szego mills, model SM-460-1, were manufactured in the fall of 1983 and systematic tests to evaluate their reliability began. Following a test period in excess of 100 hours of field testing the mill failed due to a bearing seizure.

The failure was attributed to excessive shock loading on the bearings which were allowed to move with the grinding rollers in that original design. Protection of the bearings from shock loads was immediately considered by using cushioning devices. They included both rubber bumpers and spring arrangements.

Following reassembly and field testing both cushioning arrangements showed problems. The rubber bumpers were overheated and failed while the springs deteriorated fast due to their inability to transmit torque. Evaluation of these failures lead to the conclusion that the bearing housings had to be permanently arrested and only the grinding rollers allowed to move freely. The finally adopted solution allows for roller mobility, as desired, without the need for cushioning the bearing housings.

Following the rebuilding of these mills and testing in our laboratories, with satisfactory performance, one unit was delivered to DEVCO in Sydney, N.S. in good working order.

5. MILL PERFORMANCE TESTING

5.1 EXPERIMENTAL PROCEDURE AND MATERIALS

The experiments reported here were carried out with two identical Szego mills, model SM-460-1. The unit available in our laboratories was used with all the runs performed on our premises. Naturally, the delivered mill was used to perform test runs at the Devco plant.

Only open circuit,continuous grinding was considered. Such results can be subsequently used for closed circuit evaluation and design. The test runs in our laboratory were performed at high coal concentration, 60-62% w/w of coal, which corresponds to the optimal range, with respect to concentration, of mill operation.

Dry Minto or Pittsburgh coal (same Hardgrove Grindability Index ~60) were fed to the mill via an Acrison feeder. The water to make the proper slurry consistency was injected at the mill inlet. The product of the mill was collected in the hopper of a Moyno pump until it filled-up. Following this first pass the pump was turned on for the second and subsequent passes. Samples were collected after each pass for size analysis. Flow rates through the mill were measured by calibrating either the pump or the Acrison feeder.

The runs at Devco plant were performed with locally available coal streams. Only dilute coal slurries were used and this lead to coarser products. A Moyno pump temporarily supplied by General Comminution was used to pump the slurry to the mill inlet. Products were collected for particle size analysis.

Coulter counter, HIAC PC-320 and wet sieving were used to perform particle size analysis. The samples collected at Devco plant were analysed by local personnel and results made available to General Comminution Inc.

5.2 RESULTS AND DISCUSSION

5.2.1 Experimental work performed in Toronto

Figure 2 summarizes the results obtained with Minto coal in our laboratory.

The mill rotational speed was 600 RPM and the slurry consistency 62% w/w of coal in water. Three feed rates were used: 2.2, 1.1 and 0.55 t/h. Above 45 μm sieve analysis was employed in performing size analysis on product while below 45 μm both HIAC and Coulter Counter were used.

Figure 2 shows that at 2.2 t/h the mill yields product with median size (d_{50}) of 35 μm and -80% size of 80 μm, closely matching the standard boiler size requirements. Reduction of feed rate to 1.1 t/h brings the d_{50} size down to 18 μm and -80% size to 47 μm which is the current standard for micronized coal applications. A further reduction of feed rate down to 0.55 t/h yields an ultra-fine product with a 10 μm median size. The feed material for all three runs was -1/4".

5.2.2 Experimental work performed in Sydney

Experiments were performed right after start-up on December 10th and 11th with the mill. E. Gandolfi and O.V. Mattia of General Comminution performed these experiments with the help of personnel of the Carbogel Pilot plant at Devco.

The start-up was smooth. Initially only water was pumped through the mill for one hour during which time all mechanical parts were given the opportunity to "set" under no load conditions.

Following this period experiments were performed with dilute slurries only, resulting after the sieving of ball mill product from the Carbogel pilot plant. Results are shown in Figure 3 with more tabulated in Table 1. Due to the low coal concentration mill performance was drastically compromised and increased noise observed. This would also lead to increased mill wear due to metal to metal contact.

7. RECOMMENDATIONS

(i) Due to the mill location and the noise it creates (~105dB) proper sound proofing measures have to be taken. Capital requirements are small (~$5000) to supply a noise enclosure. It is considered to be a must.

(ii) To install a disconnection switch on the starter which allows for properly starting and stopping the unit. At present time the motor feed is disconnected creating overload conditions in the starter which would cause permanent damage to the unit.

(iii) To install an interlocking switch between the motor and the feeder allowing for feeder shut-off prior to the mill. This would allow the mill to remain empty after shut-down.

(iv) Proper mill operation calls for high coal concentration. This applies to every type of mill. Otherwise poor performance and increased wear are obtained. It is suggested that at least 55% coal concentration be used, preferably 60-62% w/w. For the required product specification feed rate should be 0.55 t/h and mill rotational speed 600 RPM.

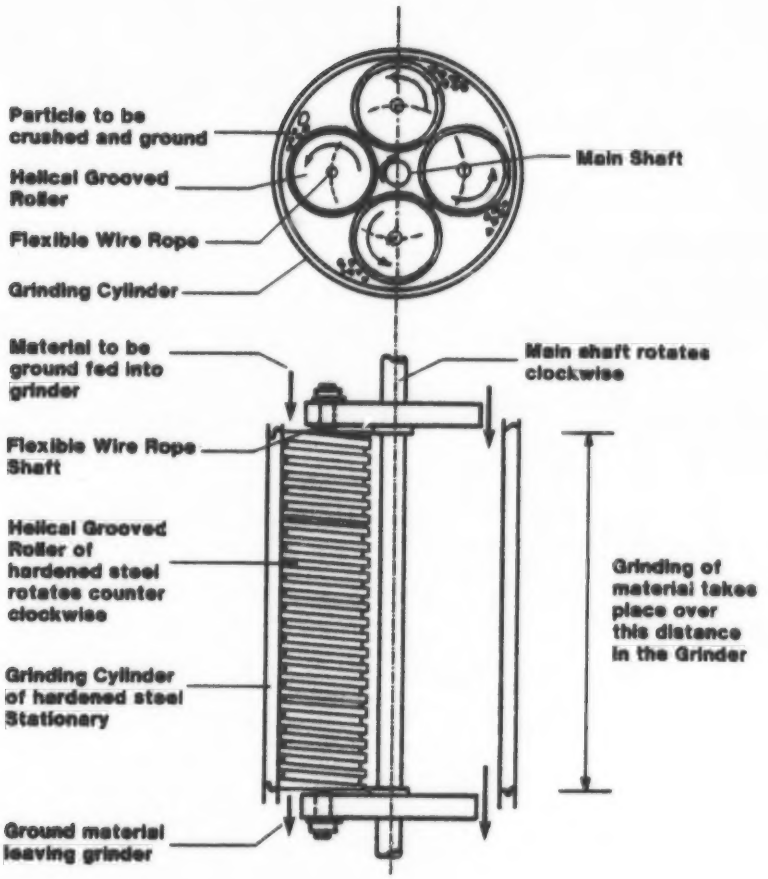
Particle to be crushed and ground
Helical Grooved Roller
Flexible Wire Rope
Grinding Cylinder
Main Shaft
Material to be ground fed into grinder
Main shaft rotates clockwise
Flexible Wire Rope Shaft
Helical Grooved Roller of hardened steel rotates counter clockwise
Grinding Cylinder of hardened steel Stationary
Grinding of material takes place over this distance in the Grinder
Ground material leaving grinder

FIGURE 1: THE SZEGO MILL

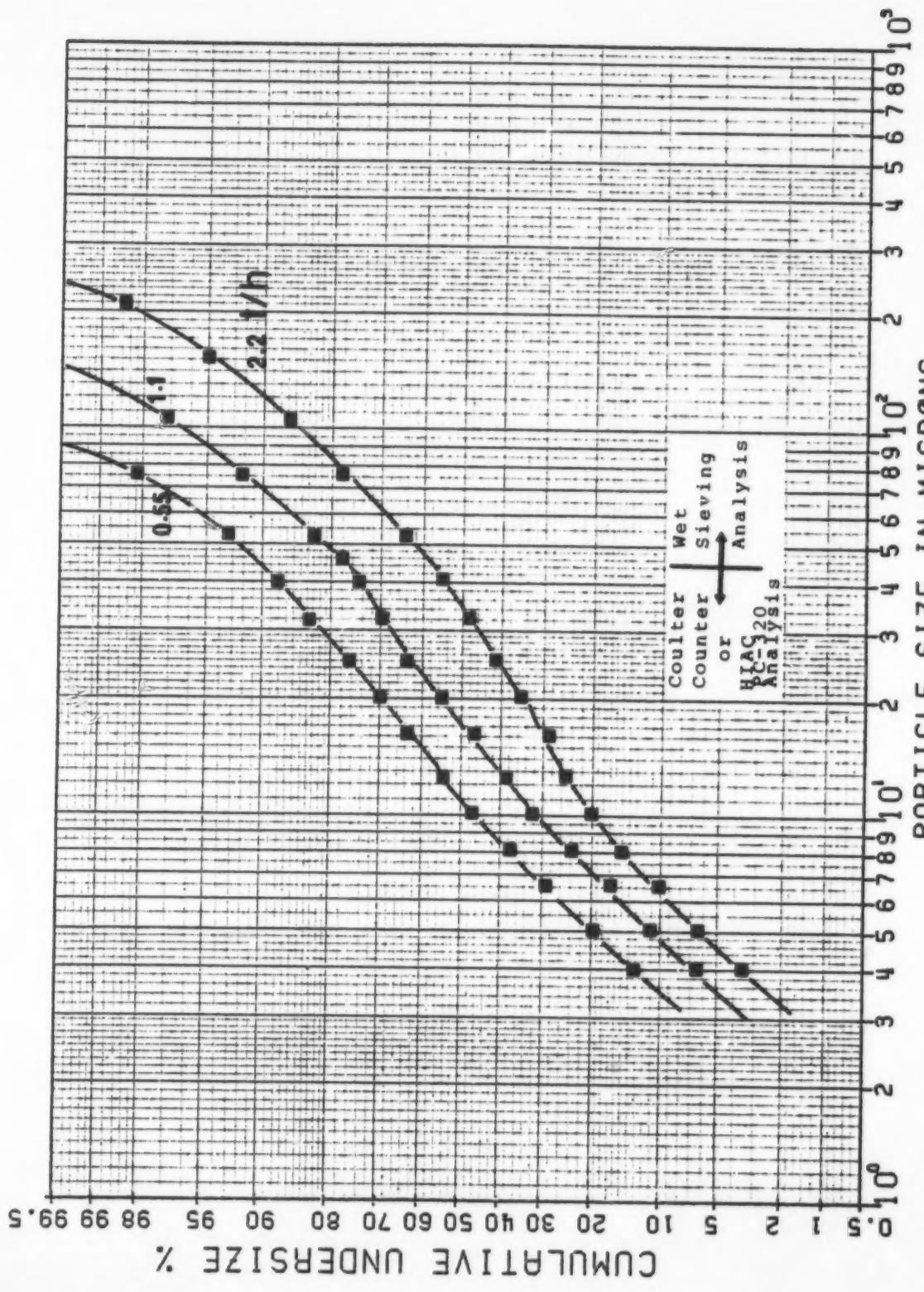

FIGURE 2: WET GRINDING OF MINTO COAL IN THE SZEGO MILL
SW-460-1; 62% W/W COAL IN WATER, 600 RPM, VARIOUS FEED RATES, 1 PASS.

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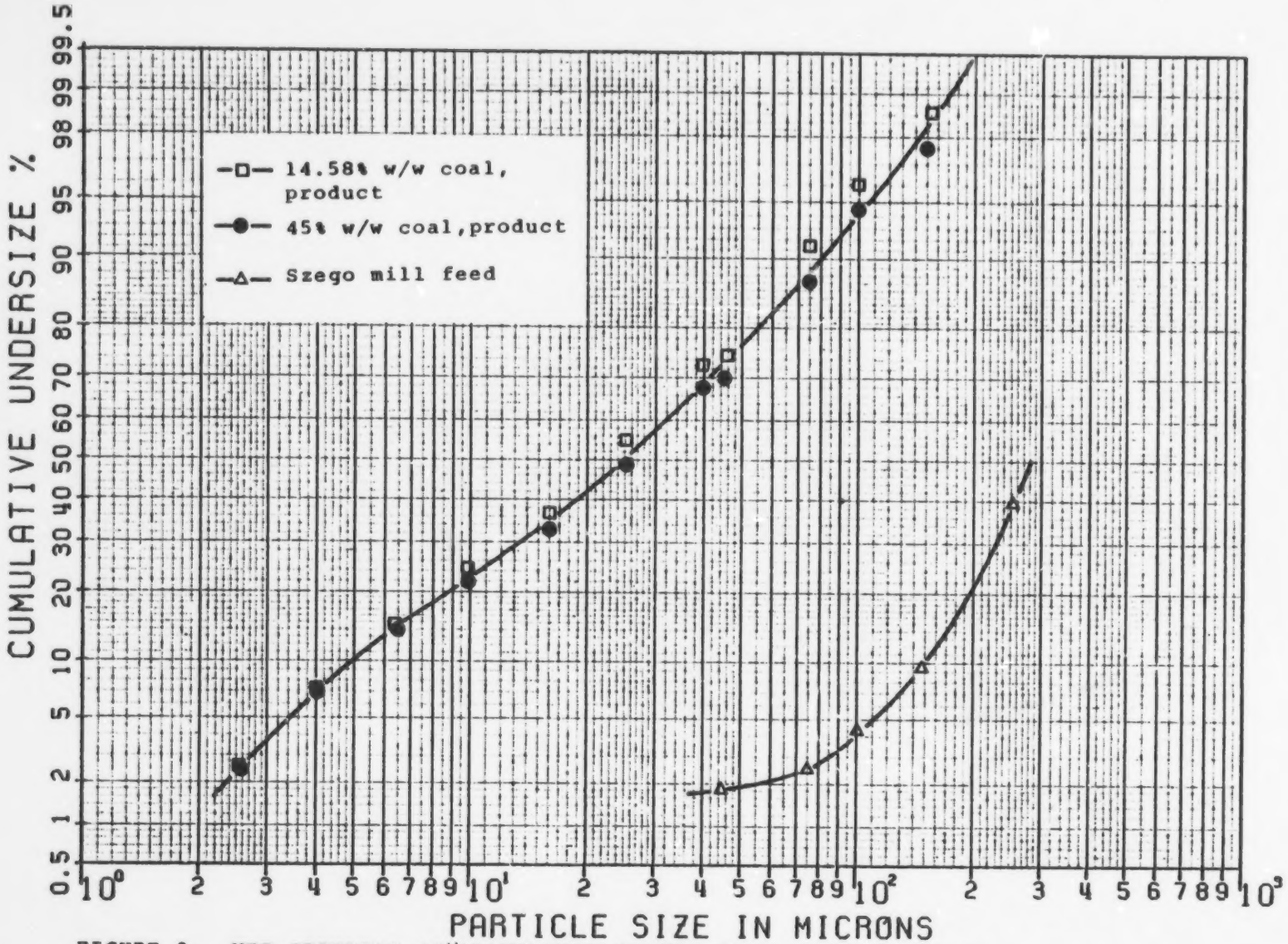
CUMULATIVE UNDERSIZE %
0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5
14.58% w/w coal, product
45% w/w coal, product
Szego mill feed
10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10² 2 3 4 5 6 7 8 9 10³
PARTICLE SIZE IN MICRONS

FIGURE 3: WET GRINDING OF HARBOUR COAL IN THE SZEGO MILL SM-460-1; 14-45% W/W COAL IN WATER, 600 RPM, .5 T/H, 1 PASS.

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TABLE 1a WET GRINDING OF HARDOUR COAL IN THE SZEGO MILL SM-460-1, 600 RPM, 0.5 t/h. (RESULTS KINDLY PROVIDED BY DEVCO)

December 10,1984

TEST No. 1

Particle Size (Microns)	Cumulative Undersize in Szego mill Discharge (6.6% Solids)	Cumulative Undersize in Szego mill Feed (14.58% Solids)
	100.00	100.00
250	99.95	33.86
150	98.63	5.70
100	96.24	3.66
74	92.60	3.26
45	74.60	3.10
40.3	72.96	
25.4	54.46	
16.0	36.70	
10.08	24.10	
6.35	14.25	
4.00	7.09	
2.52	2.46	
1.59	0	
1.26	0	

TABLE 1b WET GRINDING OF HARBOUR COAL IN THE SZEGO MILL SM-460-1, 600 RPM, 0.5 t/h. (RESULTS KINDLY PROVIDED BY DEVCO)

December 11,1984.

TEST No. 2

Particle size (Microns)	Cumulative Undersize In Szego mill Discharge (12.53% Solids)	Cumulative Undersize in Szego mill Feed (*45% Solids)
	100.00	95.18
250	99.14	39.86
150	97.56	9.52
100	94.32	4.42
74	87.16	2.50
45	69.58	1.84
40.03	67.49	
25.4	48.91	
16.0	33.40	
10.08	22.34	
6.35	13.57	
4.00	6.89	
2.52	2.44	
1.59	0	
1.26	0	

*This % solids is actually higher, due to mathematical error a lower result was obtained. (note by Devco)

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TABLE 1c WET GRINDING OF HARBOUR COAL IN THE SZEGO MILL SM-460-1, 600 RPM, 0.5 t/h. (RESULTS KINDLY PROVIDED BY DEVCO)

December 11,1984

TEST No. 3

Particle size (Microns)	Cumulative Undersize in Szego mill Discharge (10.19% Solids)	Cumulative Undersize in Szego mill Feed (27.15% Solids)
	100.00	
250	99.46	39.30
150	93.92	8.92
100	86.72	4.04
74	76.10	2.84
45	46.48	1.96
40.03	43.77	
25.4	36.54	
16.0	23.55	
10.08	14.51	
6.35	8.19	
4.00	3.78	
2.52	1.19	
1.59	0	
1.26	0	

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TABLE 1d WET GRINDING OF HARBOUR COAL IN THE SZEGO MILL SM-460-1, 600 RPM, 0.5 t/h. (RESULTS KINDLY PROVIDED BY DEVCO)

December 11,1984

TEST No. 4

Particle Size (Microns)	Cumulative Undersize in Szego mill Discharge (10.69% Solids)	Cumulative Undersize in Szego mill Feed (20% Solids)
	100.00	96.74
250	94.48	37.88
150	82.32	6.98
100	78.64	2.68
74	76.30	1.96
45	47.56	0.42
40.3	43.61	
25.4	26.63	
16.0	15.60	
10.08	9.08	
6.35	4.80	
4.00	2.14	
2.52	0.67	
1.59	0	
1.26	0	

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TABLE 1e WET GRINDING OF HARDOUR COAL IN THE SZEGO MILL SM-460-1, 600 RPM, 0.5 t/h. (RESULTS KINDLY PROVIDED BY DEVCO)

December 11,1984

TEST NO.5

Particle Size (Microns)	Cumulative Undersize in Szego mill Discharge (9.0% Solids)	Cumulative Undersize in Szego mill Feed (17.15% Solids)
	100.0	97.04
250	95.48	44.0
150	80.94	12.64
100	70.0	6.74
74	57.30	4.86
45	39.02	4.10
40.3	36.21	
25.4	21.23	
16.0	12.17	
10.08	6.56	
6.35	3.28	
4.00	1.33	
2.52	0.39	
1.59	0	
1.26	0	

- Dry Grinding
- Wet Grinding
- Homogenization

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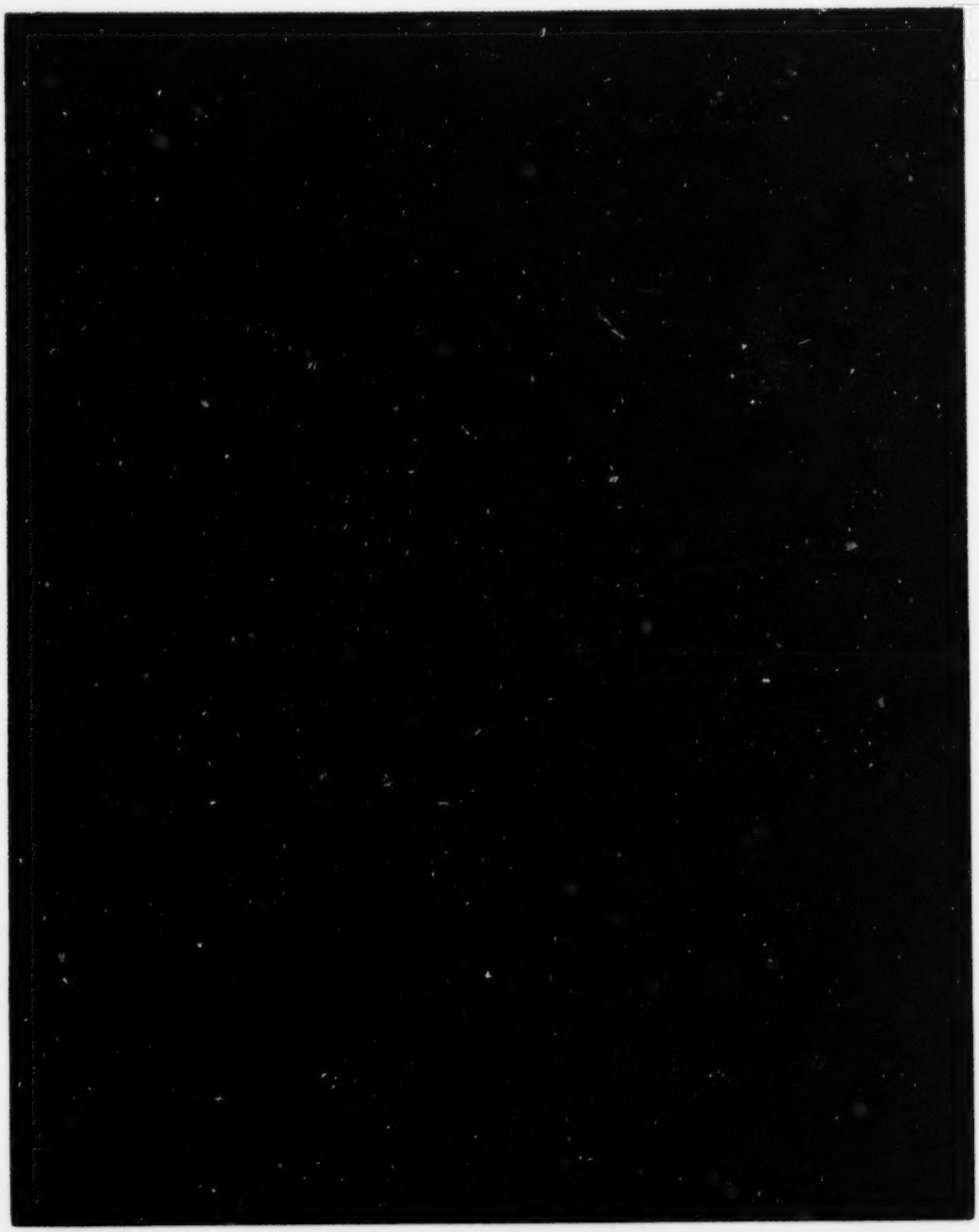

THE SZEGO MILL

AN EFFICIENT SOLUTION TO GRINDING PROBLEMS

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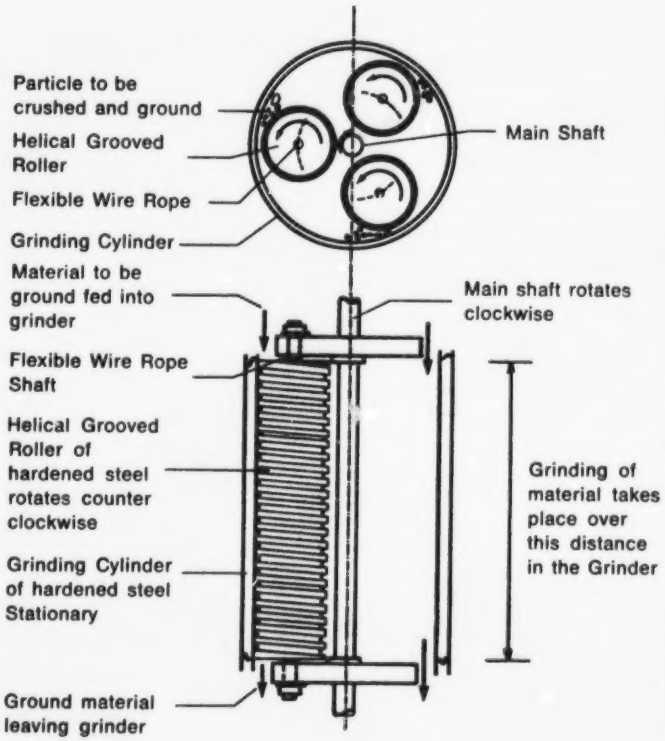
THE SZEGO MILL
HOW IT WORKS

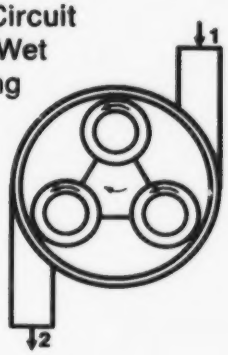

Particle to be crushed and ground
Helical Grooved Roller
Flexible Wire Rope
Grinding Cylinder
Material to be ground fed into grinder
Flexible Wire Rope Shaft
Helical Grooved Roller of hardened steel rotates counter clockwise
Grinding Cylinder of hardened steel Stationary
Ground material leaving grinder
Main Shaft
Main shaft rotates clockwise
Grinding of material takes place over this distance in the Grinder

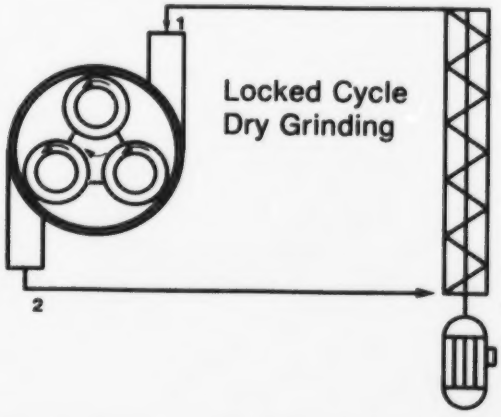
MILL CHARACTERISTICS

- High Specific Capacity
- Low Power Consumption
- Both Dry and Wet Grinding
- Slurry and Paste Grinding
- Uitrafine Grinding
- Flexibility in Operation
- Versatile applications
- Combined Operations and Processes
- Low Capital Cost

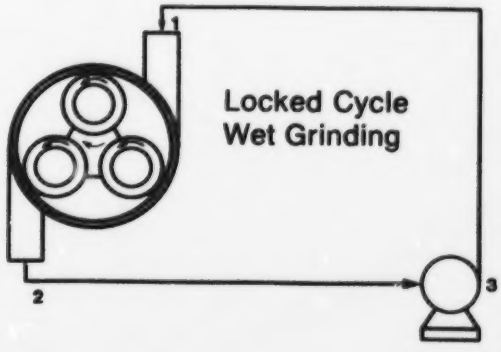
MODES OF OPERATION

Open Circuit
Dry or Wet
Grinding





Locked Cycle
Dry Grinding



Locked Cycle
Wet Grinding

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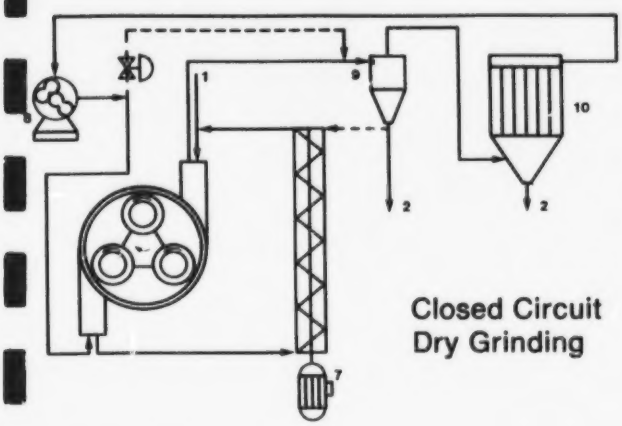
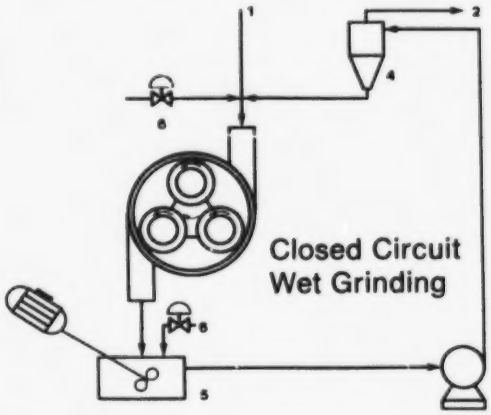


Closed Circuit
Dry Grinding



Closed Circuit
Wet Grinding

INDEX

1. Feed Material
2. Finished Product
3. Pump
4. Hydrocyclone
5. Stirred Tank
6. Solvent
7. Screw Conveyor
8. Blower
9. Cyclone / Classifier
10. Baghouse

SZEGO MILLS AVAILABLE

MODEL	DIAMETER		HEIGHT		CAPACITY* kg / h of coal slurry
	MM	IN.	MM	IN.	
SM-220-1 SINGLE STAGE	280	11	457	18	900
SM-280-3 THREE STAGES	360	14	1220	48	3600
SM-460-1 SINGLE STAGE	560	22	508	20	4500

* Wet Grinding of Coal from 3 mm to 80% passing 200 mesh (74 μm), 60-70% coal.

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- Custom Grinding and Materials Testing
- Pilot Plant Set-ups for Specific Applications
- Particle Processing, Classification, Characterization
- Research and Development Services

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- Wet Grinding
- Homogenizatio

TYPICAL GRINDING APPLICATIONS

MATERIAL	WET GRINDING	DRY GRINDING	HOMO-GENIZA-TION
CARBONACEOUS			
Coal / Coal Slurries	○	○	○
Coke, Lignite, Peat	○	○	○
Graphite		○	
MINERALS / FILLERS			
Talcs		○	
Mica	○	○	
Clays / Ceramics		○	
Bauxite		○	
Limestone	○	○	
PIGMENTS			
Iron Oxides	○		
Organic Pigments	○		
Metallic Pigments	○		
METAL POWDERS			
Aluminum pastes	○		
Copper pastes	○		
Zinc pastes	○		

MATERIAL	WET GRINDING	DRY GRINDING	HOM GENIZ ON
CHEMICALS / PLASTICS			
Ion Exchange Resins		○	
Toners		○	
Detergents	○	○	○
FOOD / ADDITIVES			
Cocoa Products	○	○	○
Soy Beans	○	○	
Oilseeds / Grains	○	○	
WASTES / BYPRODUCTS			
Paper / Cellulose		○	○
Fibrous materials		○	○
Wood Chips		○	

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• Research and Development Services

G. C. I.
General Comminution Inc.

- Dry Grinding
- Wet Grinding
- Homogenizati

TYPICAL GRINDING APPLICATIONS

MATERIAL	WET GRINDING	DRY GRINDING	HOMO-GENIZA-TION
CARBONACEOUS			
Coal / Coal Slurries	○	○	○
Coke, Lignite, Peat	○	○	○
Graphite		○	
MINERALS / FILLERS			
Talcs		○	
Mica	○	○	
Clays / Ceramics		○	
Bauxite		○	
Limestone	○	○	
PIGMENTS			
Iron Oxides	○		
Organic Pigments	○		
Metallic Pigments	○		
METAL POWDERS			
Aluminum pastes	○		
Copper pastes	○		
Zinc pastes	○		

MATERIAL	WET GRINDING	DRY GRINDING	H G
CHEMICALS / PLASTICS			
Ion Exchange Resins		○	
Toners		○	
Detergents	○	○	
FOOD / ADDITIVES			
Cocoa Products	○	○	
Soy Beans	○	○	
Oilseeds / Grains	○	○	
WASTES / BYPRODUCTS			
Paper / Cellulose		○	
Fibrous materials		○	
Wood Chips		○	

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MAPS NOT

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CARTES

OMISES